Centro Euro-Mediterraneo per i Cambiamenti Climatici

Seasonal-Decadal Predictions at CMCC

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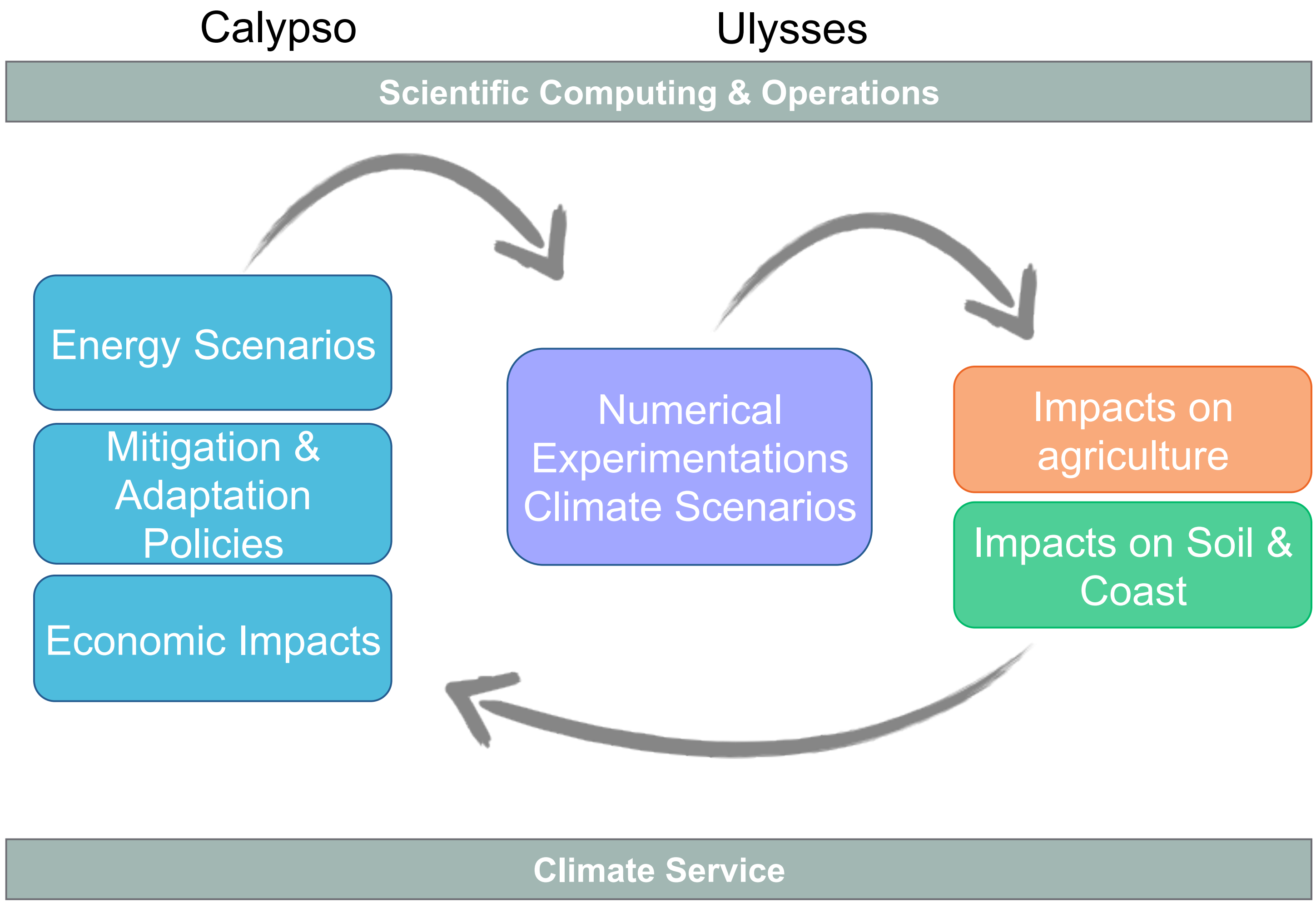
Centro Euromediterraneo per i Cambiamenti Climatici

- **CMCC was established in 2005 by a group of Italian Research Institutions** (Istituto Nazionale di Geofisica e Vulcanologia, Fondazione Eni Enrico Mattei, Università degli Studi del Salento, Centro Italiano Ricerche Aerospaziali, Universita' di Venezia, Università degli Studi del Sannio)

- **CMCC is the Italian Research Centre on Climate Science and Policy**. Supported by the Italian Ministry for the Environment Land and Sea, the Ministry for Education, University and Research and the Ministry for Economy

- **CMCC hosts the IPCC Italian Focal Point**

3. Six Integrated Divisions



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INGV Istituto Nazionale di Geofisica e Vulcanologia

The CMCC/INGV Earth System Model

ATMOSPHERE (dynamics, physics, prescribed gases and aerosols)

ECHAM4/5 (Roecker et al 1996, 2003)

LAND, VEGETATION and TERRESTRIAL CARBON

SILVA (Alessandri, 2006; Zeng et al 2004; Ducoudre et al 1993)

Oasis 2/3 Coupler
(Valcke et al 2004)

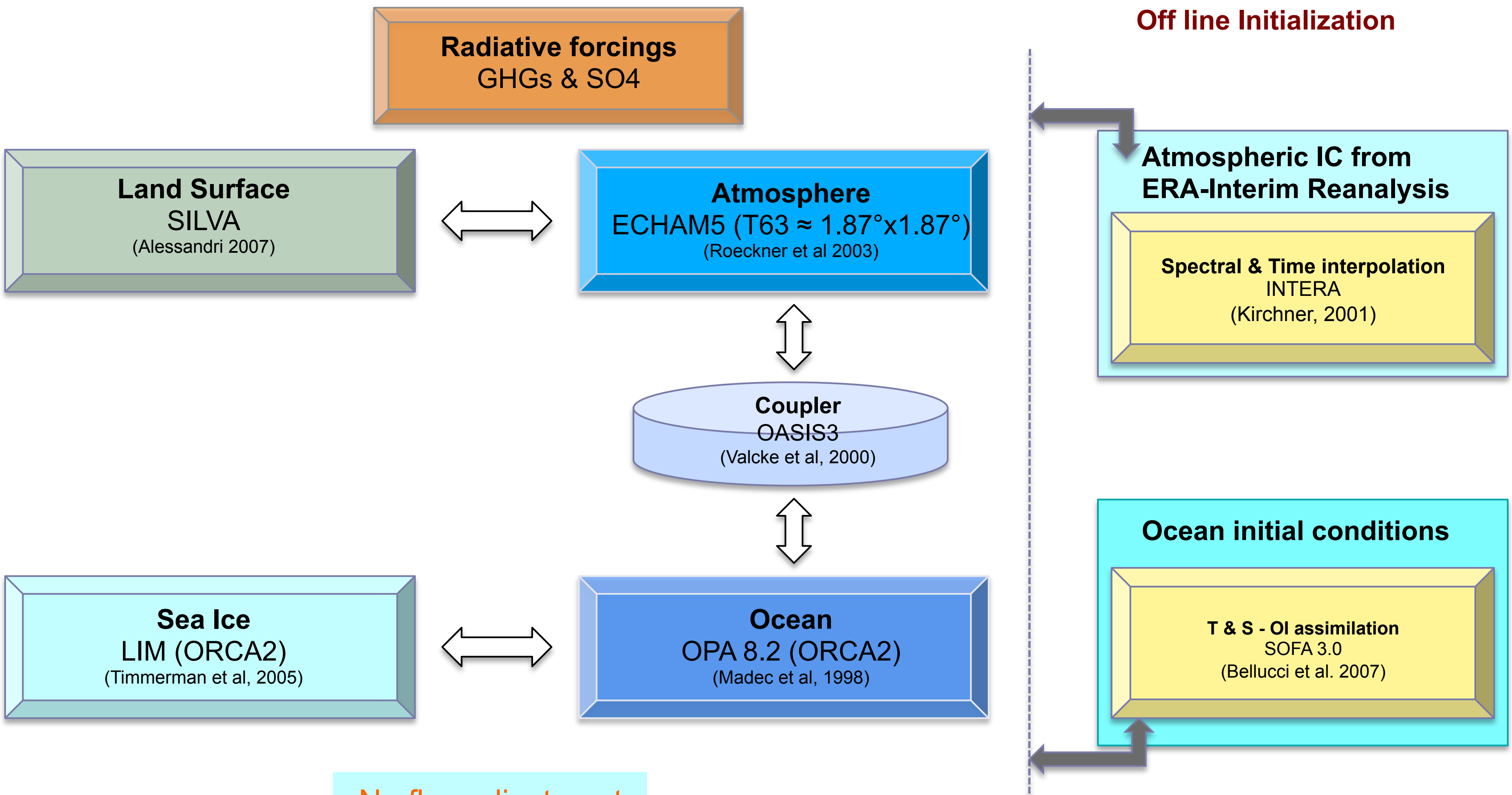
Ocean (dynamics and physics)
OPA8.2/NEMO (Madec et al 1998)

SeaIce: LIM (Timmermann et al 2005)

Marine Biogeochemistry and Ocean Carbon:

PELAGOS (Vichi et al 2006a,b)

The current configuration of the CMCC forecasting system



No flux adjustment

Forecasting experimental set-up

Four Start Dates every year:
February, May, August and November

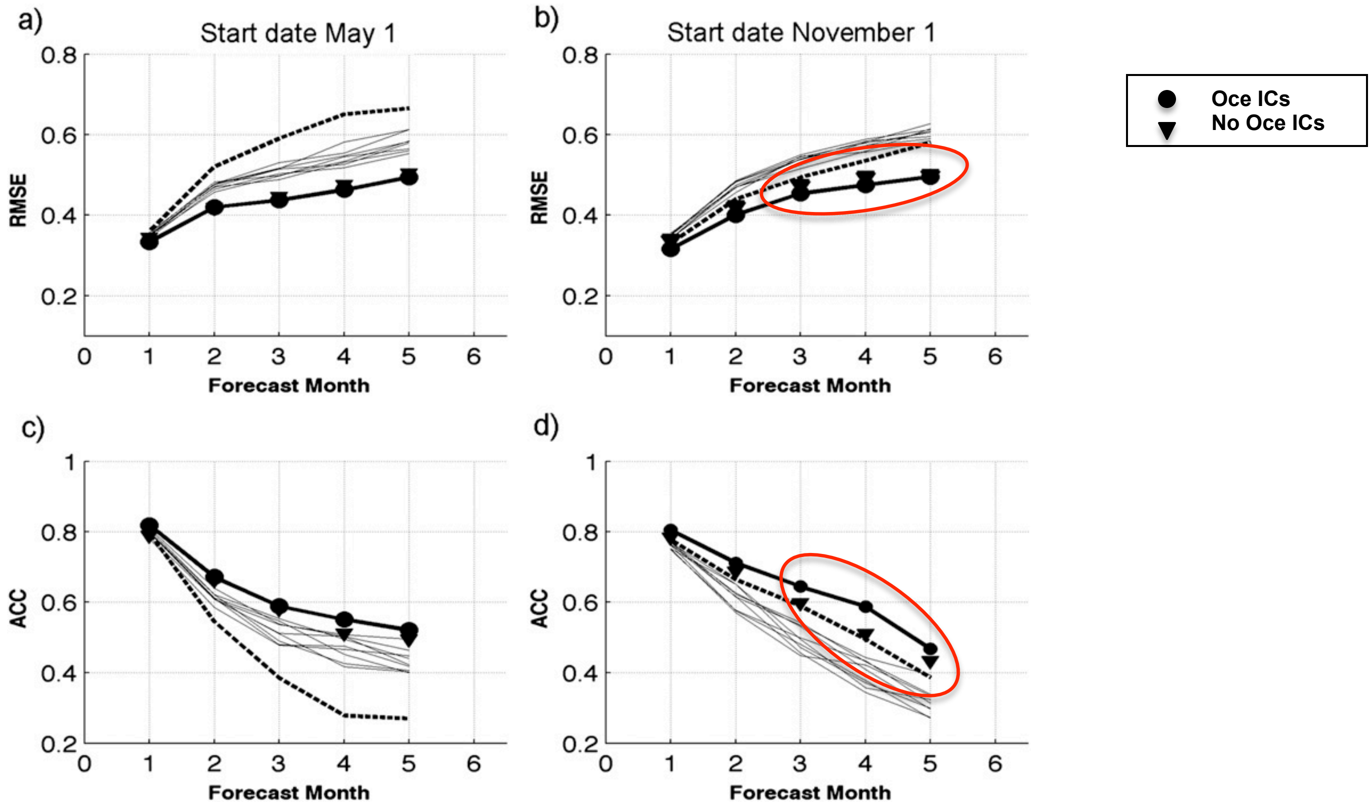
Atmospheric and SST perturbations → 9 perturbed ICs for each start date, each year

Sea Ice cover Ini. Cond. inferred from SST IC at the forecast start

Forecasts in the past have been performed for the period **1960-2005**

ensembles of **9 forecasts**, each integration **7 months** long

Tropical Pacific SSTA: ACC and RMSE

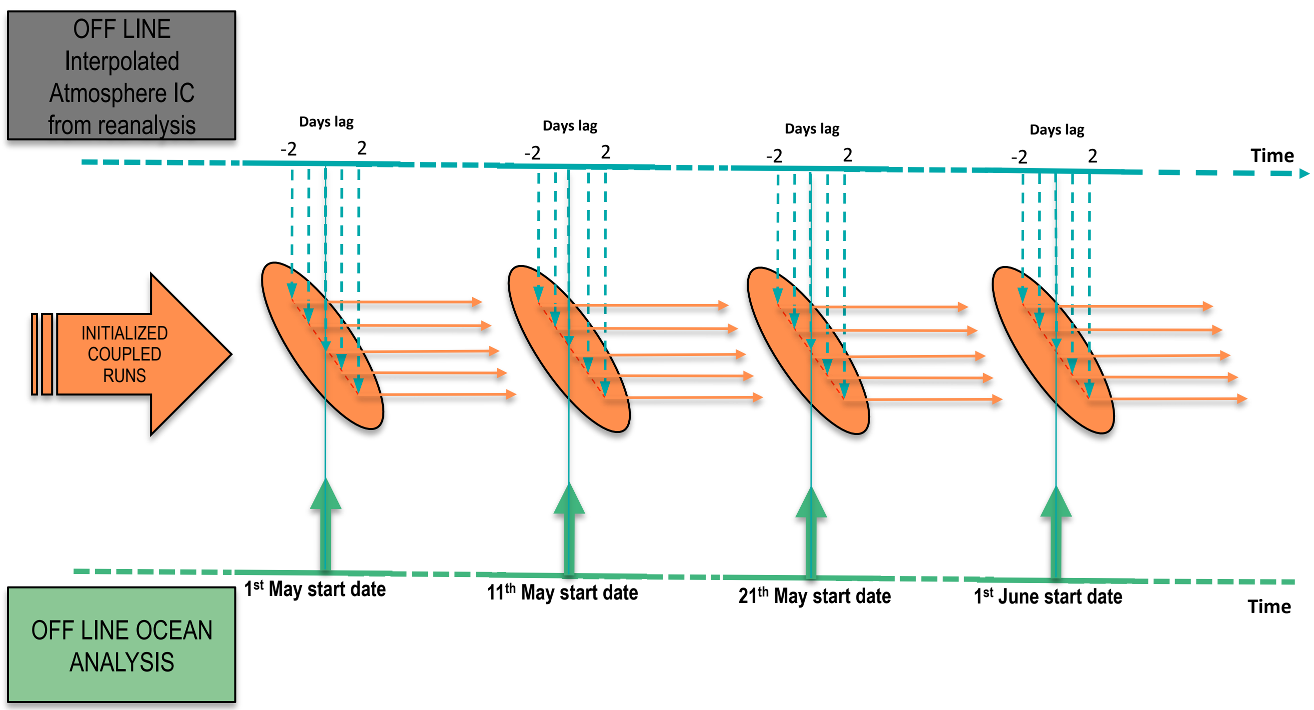


Alessandri et al, 2010a (Mon. Wea. Rev.)

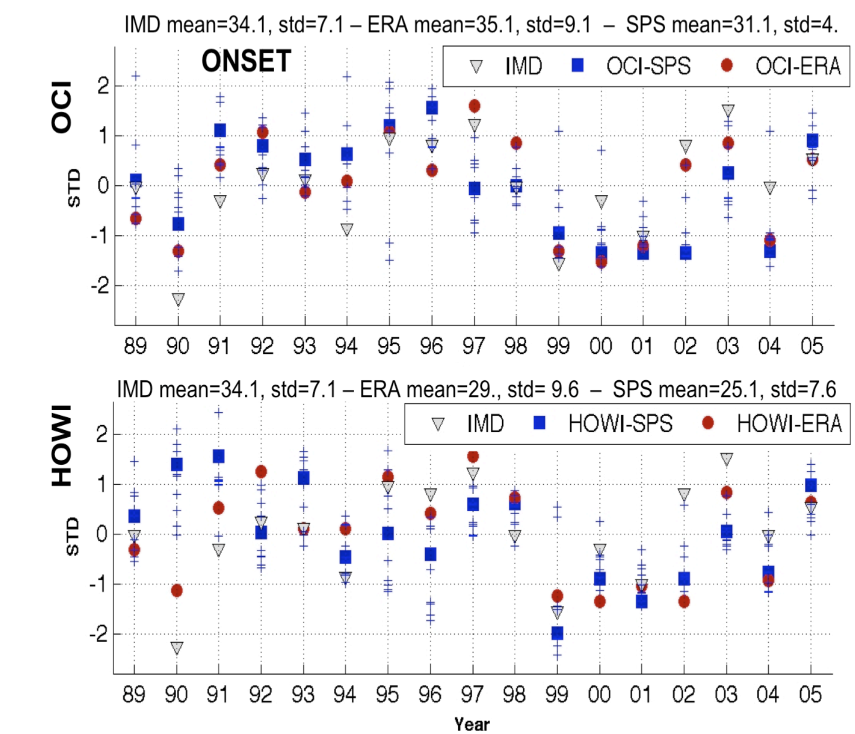
Intra-seasonal hindcasts

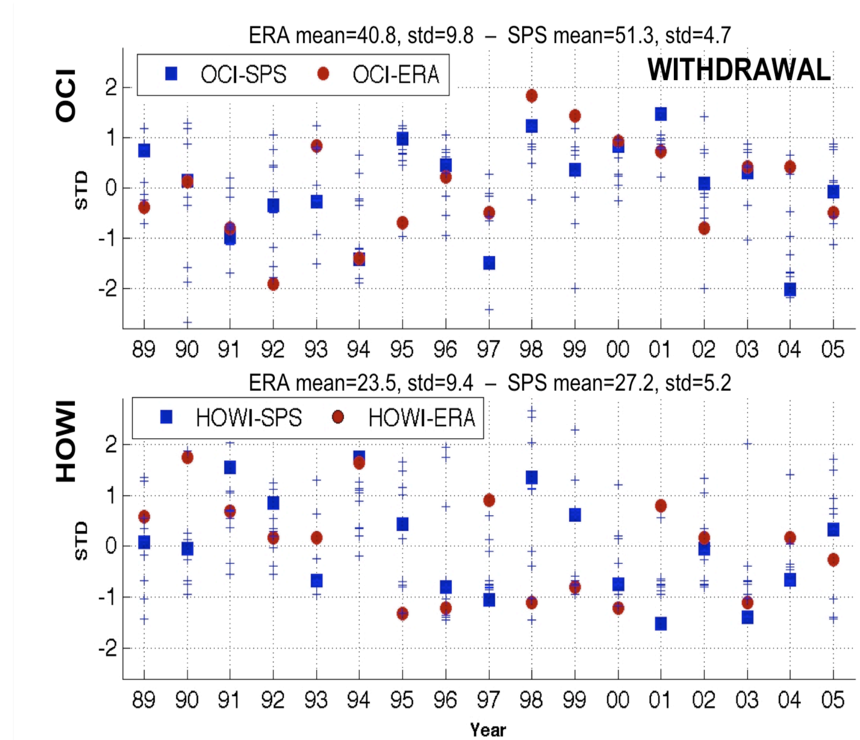
Hindcasts performed for the period 1989-2009
3 start dates each month for each year
Ensembles of 5 forecasts, each integration 5 months long

5 atmospheric ICs from lagged days (-2:0:+2) → 5 perturbed i.c. for each start date, each year



Indian Summer Monsoon (ISM) Onset and Withdrawal days





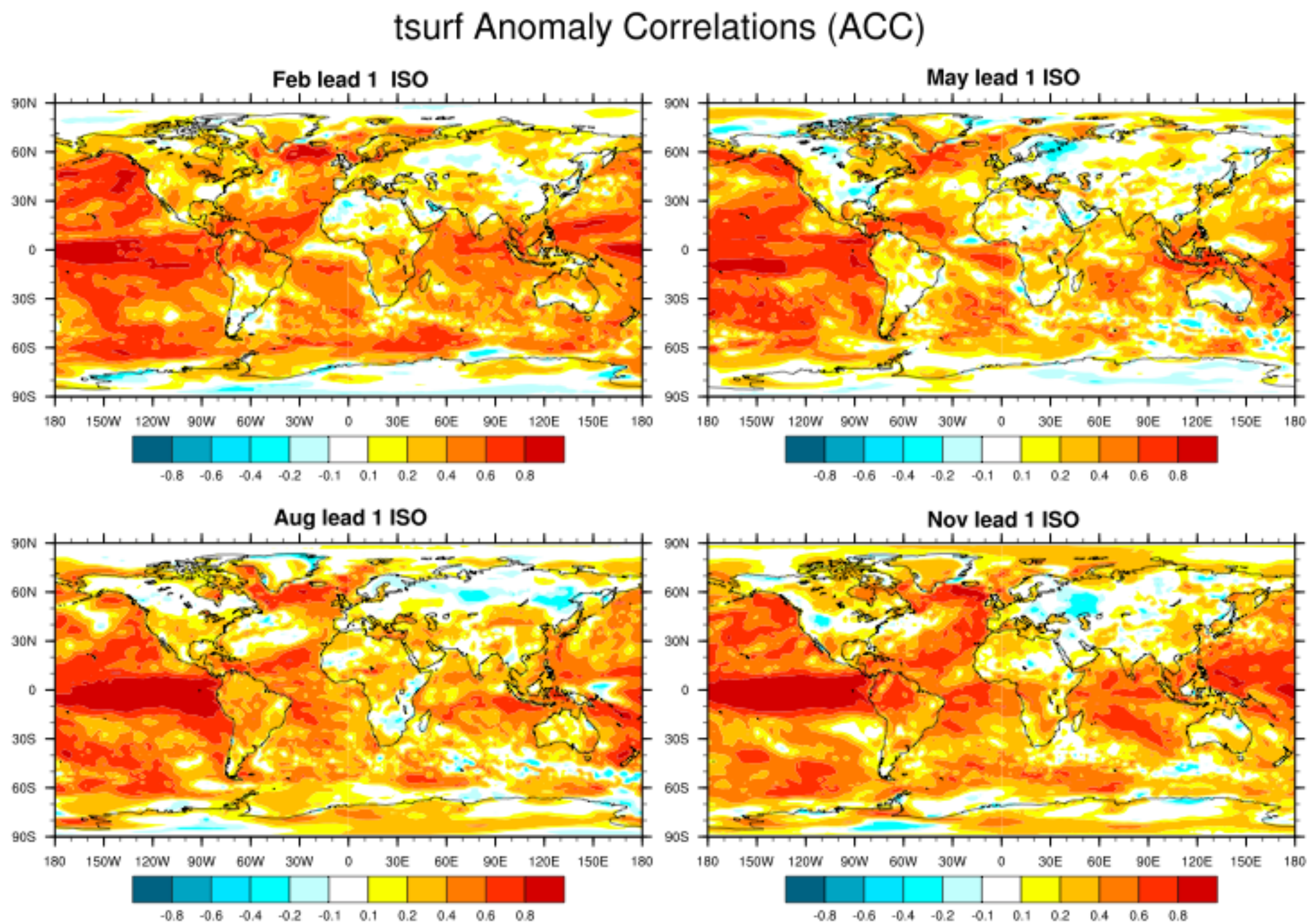
		ERA-Interim OCI	ERA-Interim HOWI	IMD Onset
FORECASTS	OCI	*0.65***		*0.70***
FORECASTS	HOWI		*0.52***	*0.32**
	IMD Onset	*0.80***	*0.73***	

(**) 5% - (*) 10% Significance level

		ERA-Interim OCI	ERA-Interim HOWI
FORECASTS	OCI	*0.46 **	
FORECASTS	HOWI		*0.15*

Courtesy of Andrea Alessandri

Seasonal to decadal prediction for sub-saharan Africa



Alessandri et al, 2010a (Mon. Wea. Rev.)

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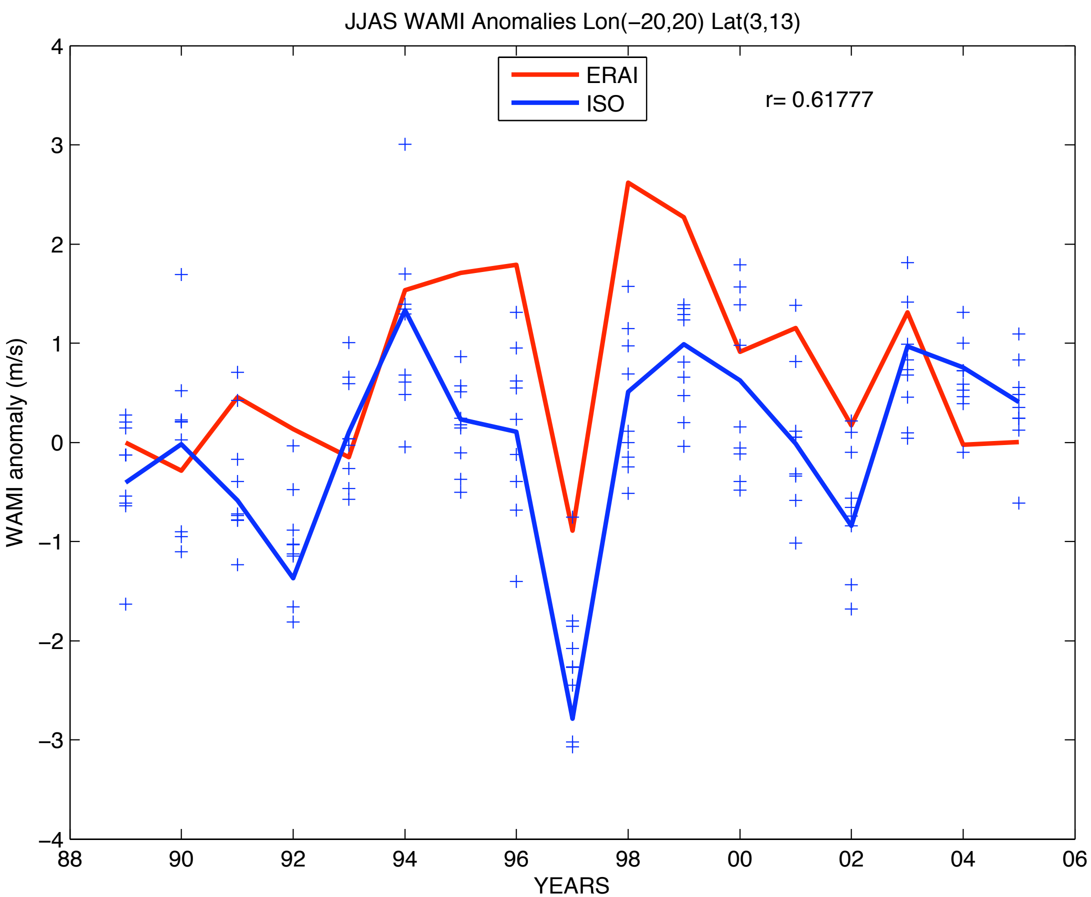
ClimAfrica

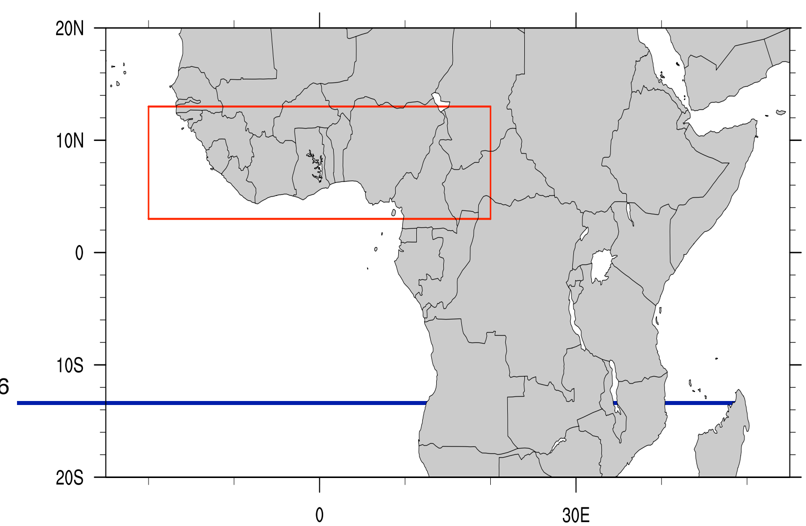
Seasonal to decadal prediction for sub-saharan Africa

West African Monsoon Index



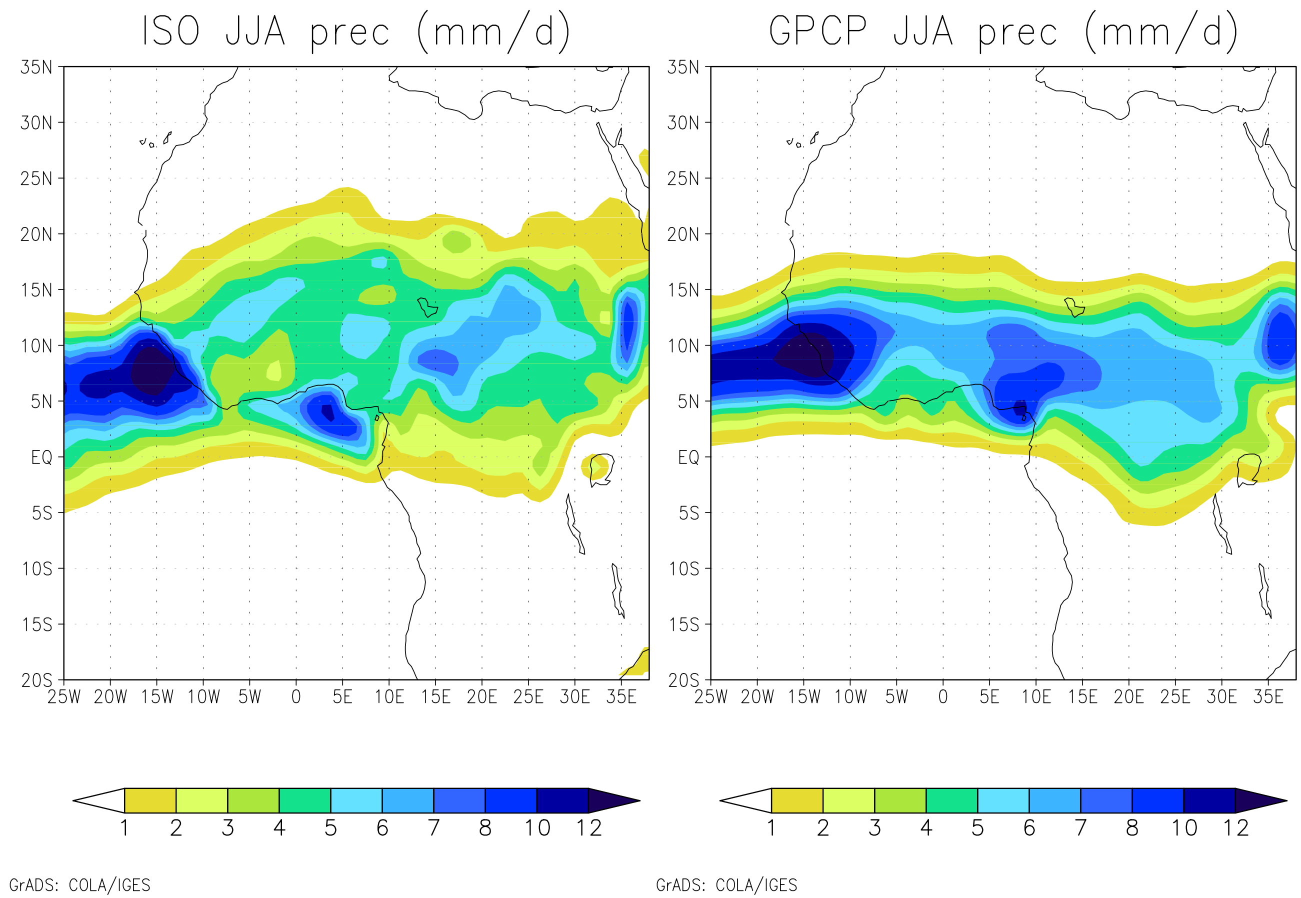
$$WAMI = \left|\vec{u}_{850}\right| - u_{200}$$

Fontaine et al., 1995 J Clim



Seasonal to decadal prediction for sub-saharan Africa

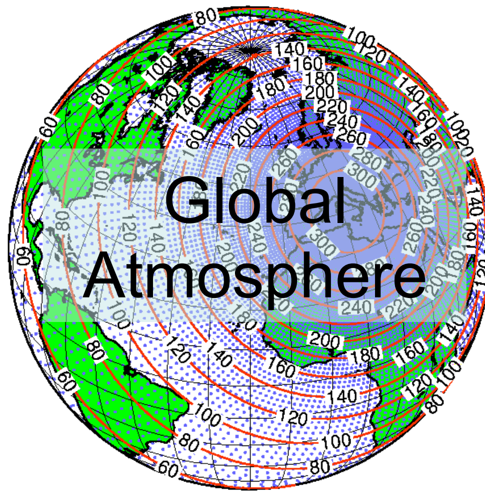
Precipitation (mm/day)
(May start date, lead 1- JJA)



The CMCC-MED climate scenario simulations:

climate simulations and projections with interactive Mediterranean Sea

The model: CMCC-MED



ATMOSPHERE ***(dynamics, physics, prescribed gases and aerosols)***

ECHAM5 T159 (T255)

~ 80 Km (60 Km)

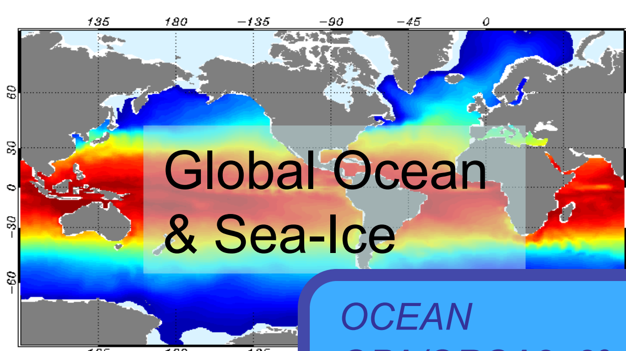
Heat Flux
Water Flux
Momentum

SST
Sea-ice

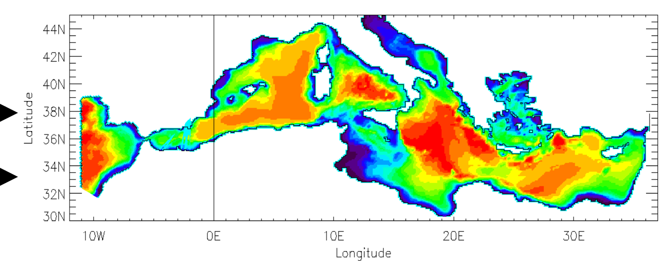
COUPLER Oasis 3

SST

Heat Flux
Water Flux
Momentum



T, S,
u, v, η



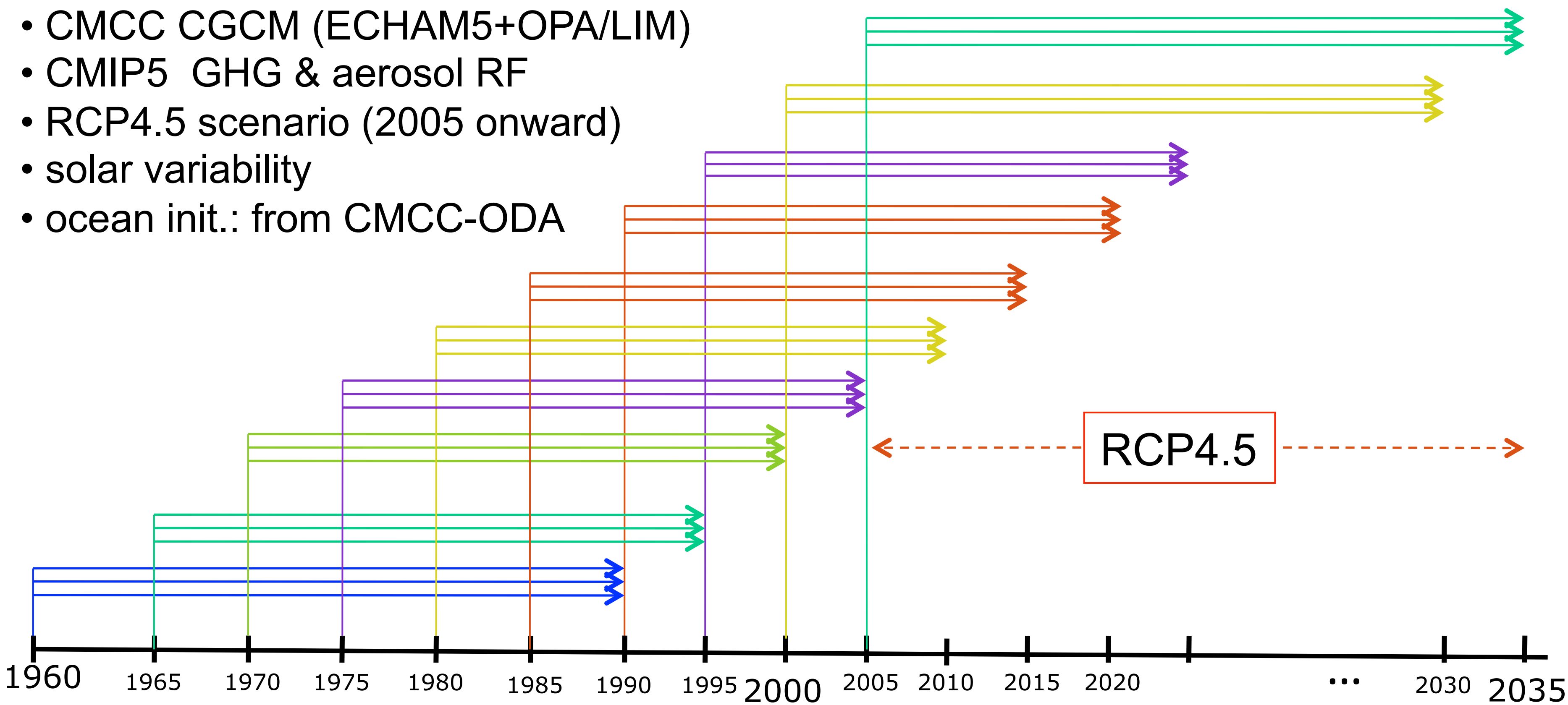
OCEAN
OPA/ORCA2 2º (1/4°)
SEA-ICE: LIM

OCEAN Mediterranean
NEMO/MFS 1/16°, 71 vert. levs
Oddo et al. (2009)

Decadal Predictions: experiment setup

◆ 30-year hindcast/forecast simulations grouped into 3-members ensembles, for different start dates.

- CMCC CGCM (ECHAM5+OPA/LIM)
- CMIP5 GHG & aerosol RF
- RCP4.5 scenario (2005 onward)
- solar variability
- ocean init.: from CMCC-ODA



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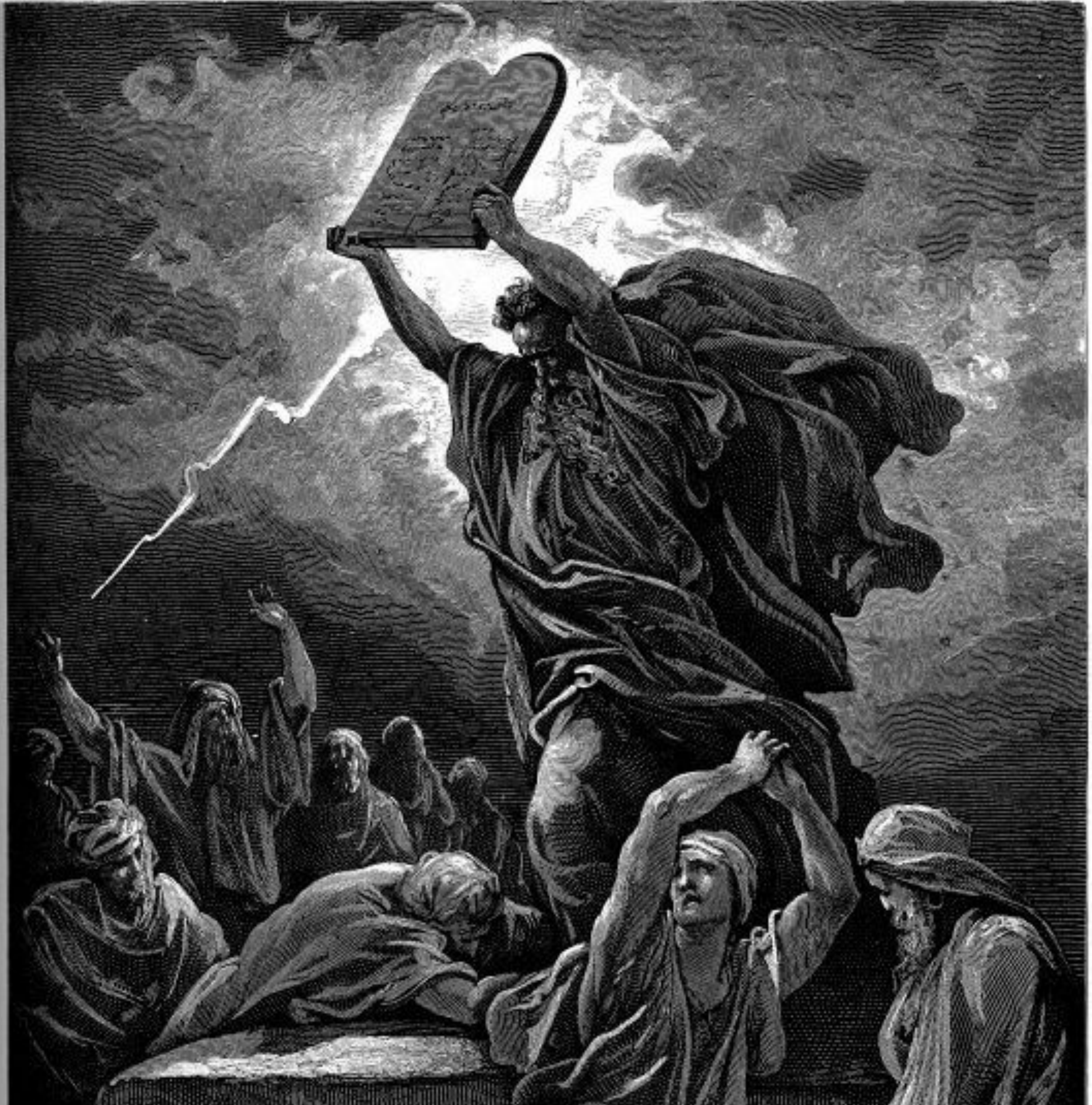
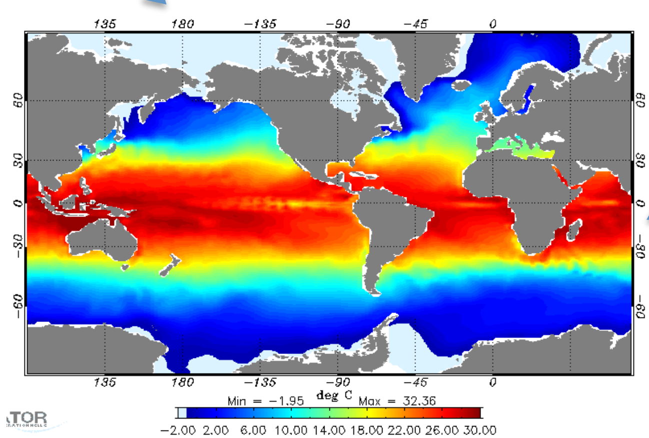


Initialization

- Ocean Initialization: Full fields from CMCC ocean analyses (OI and 3DVAR)
- Sea-ice: model climatology

Sea-Ice & Snow thickness
init.: model climatology



OCEAN: different analyses (strategy adopted to generate the ensemble spread)

CMCC - OI

CMCC – 3DVAR1

CMCC – 3DVAR2

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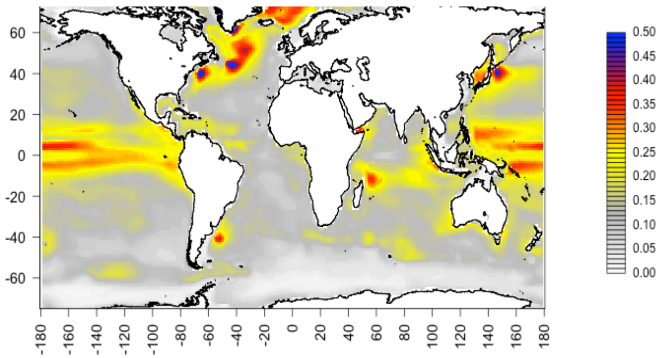
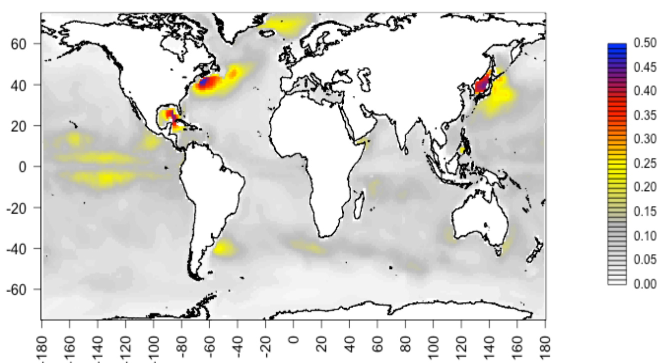
The three Global Ocean analysis systems at CMCC

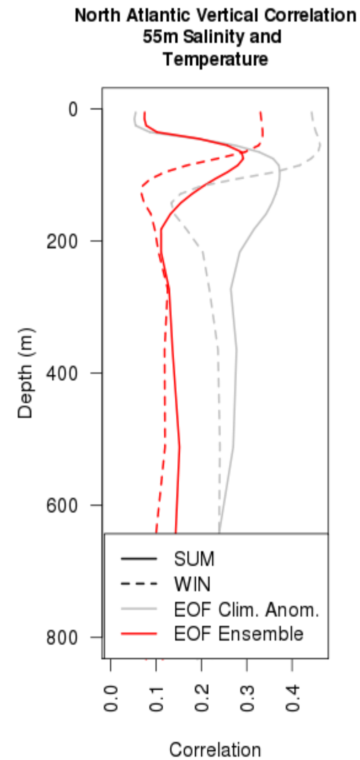
1) **Optimal Interpolation (OI)** analysis system assimilating hydrographic data of (T, S) from EN3 dataset and using bivariate EOFs computed from model climatological anomalies for representing model-error vertical covariances (Bellucci et al., 2007, Masina et al., 2011);
2) **3DVAR** data assimilation system assimilating hydrographic data of (T, S) from EN3 dataset and along-track altimetric observations (1992-onward). The same set of EOFs as in the OI is used (Storto et al., 2011);
3) **3DVAR** data assimilation system as the previous but with a different set of vertical EOFs, derived from the differences between 6 ensemble members and the ensemble mean within an **ensemble variational assimilation experiment (1993-2005) with perturbed observations, surface forcing and model parameterization tendencies**.

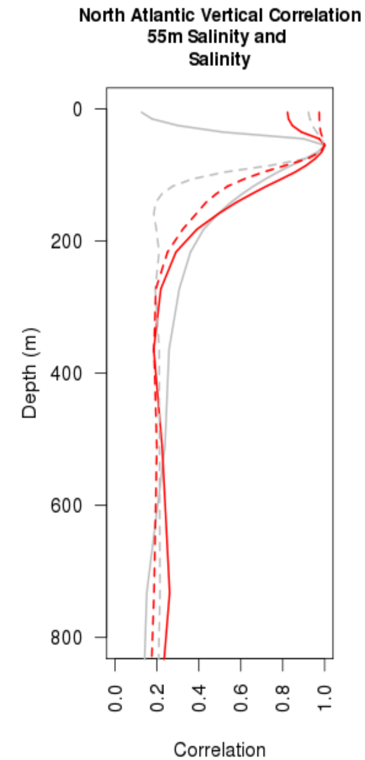




On the left: 0-100 m summertime temperature st. dev. for EOF first set (top) and EOF second set (bottom). The latter shows a smaller error signal and peaks only in mesoscale areas.

On the right: North-Atl. averaged profiles of summer and winter model-error vertical (cross-)correlations between 55 m salinity and the other model levels for the two EOF sets. The ensemble derived set exhibits a stronger salinity upper ocean auto-correlation in Summer, but generally a smaller cross-correlation.





The new global 3DVar assimilation

❖The 3D-Var system (Dobricic & Pinardi, 2009) used for the Mediterranean Sea has been extended to the global ocean to replace the former OI analysis (Storto et al., 2011)

❖Validation has been done mainly on the coarse (2°x2°) resolution but we have started the production also at eddy-permitting resolution (1/4°x1/4°)

❖The assimilated set of observations includes all the in-situ observations (XBT, Argo, Buoys,etc) and Sea Level Anomalies (1992-onwards) assimilated through local hydrostatic adjustments

❖Use of model-derived MDT: calculated from reanalyses and short-range forecasts when only in-situ observations were assimilated; then adjusted through OI to account for SLA obs minus guess bias, assumed that the MDT bias is the principal contributor (Dobricic, 2005). Impact of this MDT with respect to the observations-based MDT (RIO04, Rio and Hernandez, 2004) is generally positive.

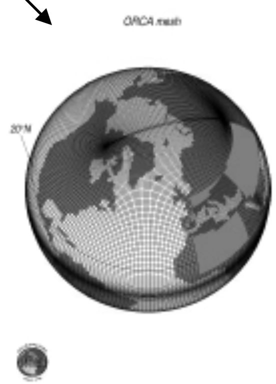
❖Observations are quality-checked and thinned; observations error is assigned as a function of instrument (in-situ), satellite, closeness to Equator

The new Global Ocean Data Assimilation System at CMCC

In Situ Data:
WOD05,WOCE,ARGO,etc.
(Temperature and Salinity)

Forcing: ERA40 daily fluxes

3D-Var
Dobricic & Pinardi, 2008



NEMO
ORCA025

EOFs:
Vertical from Model

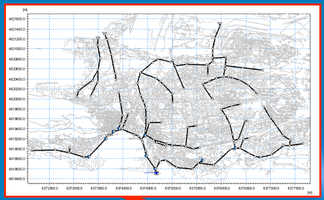
Altimetry Data:

The ADRICOSM-STAR new coastal integrated observational and modelling approach

Italian Ministry for the Environment, Land and Sea

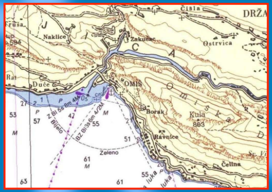
Atmospheric and climate models

Urban waters

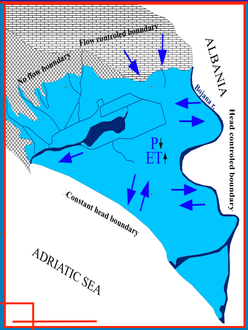


Coastal area

River



Underground Waters



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Data QC, Model interfaces
Geoportal

Monitoring, forecasting and Climate scenario impacts

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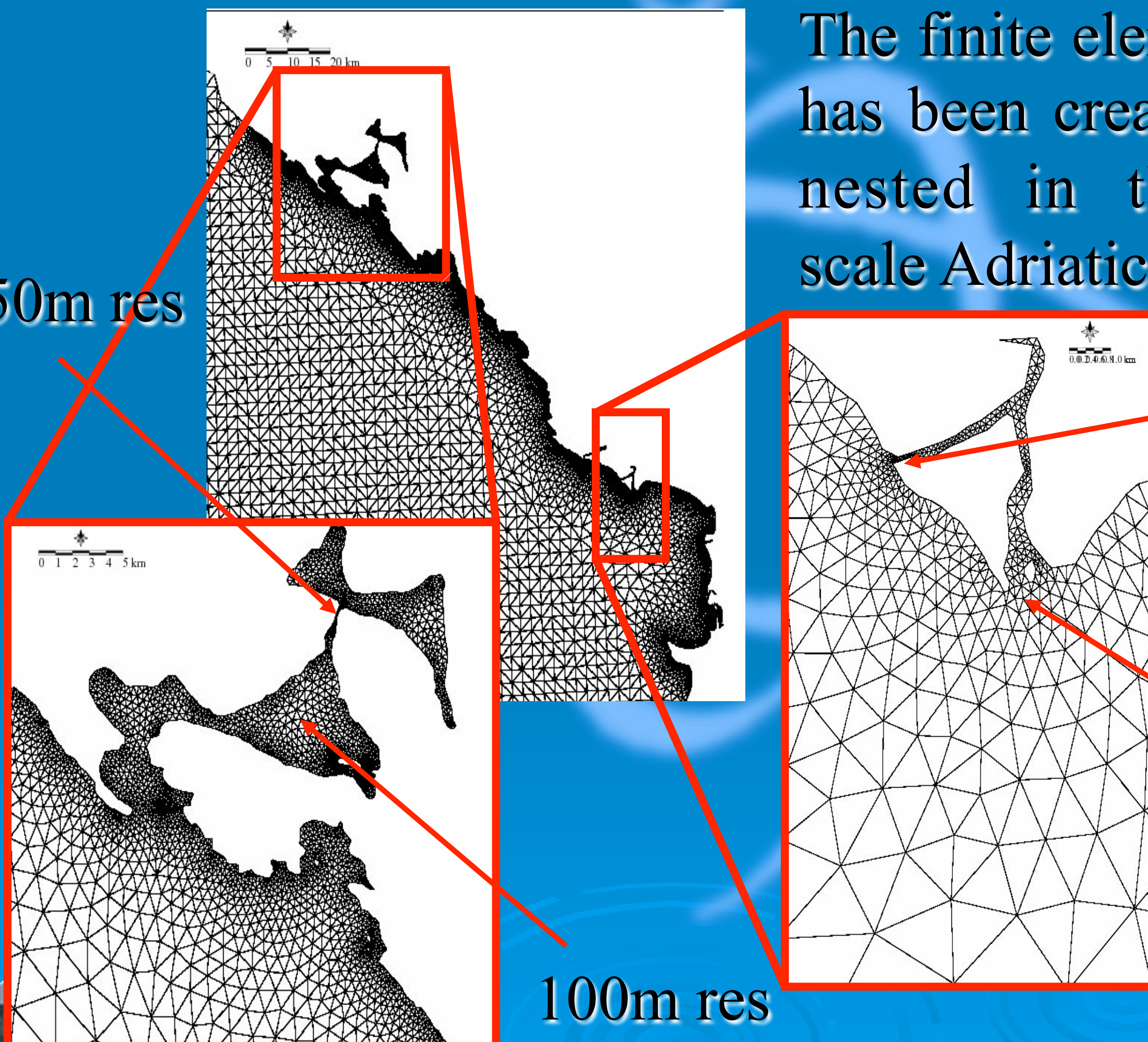
Montenegro coastal strip modelling

Italian Ministry for the Environment, Land and Sea

The finite element grid has been created to be nested in the large scale Adriatic model



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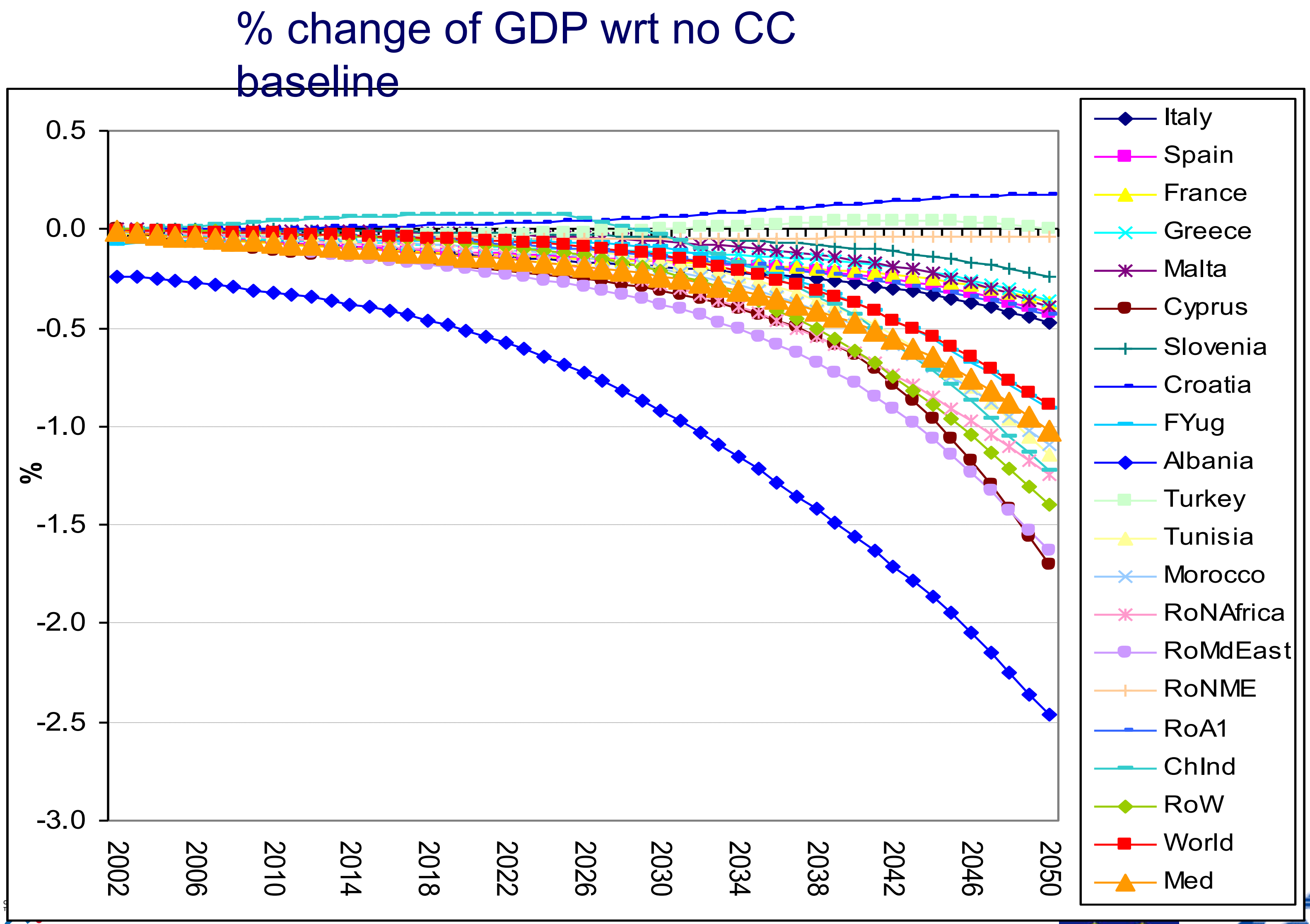
Climate Change Impacts on GDP



Sustaining and directing the research effort

Funding for Earth Systems research is stationary or decreasing.

University programs, with their reliance on individually funded research, are too small to engage in a global programmatic approach.

Research spending from those institutions that do have scale – e.g. defense budgets and private sector entities – is significantly lower than it used to be.

We are not increasing our investments in research right at the time when we need to generate new intellectual capital that can help us manage both the planet and our economic activities in the 21st Century.

A new international research paradigm

We need to identify the new questions. What are the big scientific and technological questions that will make a real difference to policy and investment decisions in the coming decade, and that can drive the research agenda of the next generation of researchers and scientists?

We need to mobilize new sources of funding. We need to be able to articulate the scale of funding needed. What is the scale of that funding? How does it compare to other efforts to accomplish other advancements in knowledge and technology?

We need new global institutional solutions to deliver the support this research deserves. What forms of global public-private partnerships do we need to ensure the private sector invests for the long term? What institutional arrangement should we set in place?

Future Plans

- Near Climate Model, Seasonal Forecasts: T255/321 and 0.25 NEMO
- Ocean Data Assimilation at 0.25
- Short term Ocean Predictions: Atlantic 1/24, Mediterranean 1/32 (~ 1 months)
- Integrate:
  - NCR Model with CGE models
  - Land-use model